

FARM MACHINERY AND PROCESSES MANAGEMENT IN SUSTAINABLE AGRICULTURE



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FARM MACHINERY AND PROCESSES MANAGEMENT IN SUSTAINABLE AGRICULTURE

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4.8. THE EFFECT OF DIGESTATE FERTILIZATION ON QUALITY AND STRENGTH ON RAPESEEDS	279
Milan KOSZEL, Artur PRZYWARA, Alexandros Sotirios ANIFANTIS, Edmund LORENCOWICZ	
4.9. TEXTURE CHANGES IN PEAR CULTIVARS DURING STORAGE	285
Rafał NADULSKI, Marian PANASIEWICZ, Katarzyna WRÓBLEWSKA-BARWIŃSKA, Tomasz GUZ	
4.10. THE EFFECT OF CARROT STORAGE ON THE PROPERTIES OF CARROT-APPLE JUICE	291
Arkadiusz RATAJSKI, Ewa GOLISZ, Emilia GAIK, Malwina TRZCIŃSKA	
4.11. THE EFFECT OF ORGANIC FARMING ON CARROT JUICE PROPERTIES	297
Arkadiusz RATAJSKI, Jędrzej TRAJER, Monika JANASZEK-MAŃKOWSKA, Katarzyna DEMIANIUK, Izabella KOSTEWICZ	
4.12. THE IMPACT OF TWO YEARS OF PLANT PROTECTION IN THE GERANIUM WITH SPECIAL EMPHASIS ON GREENHOUSE WHITEFLY (<i>Trialeurodes vaporariorum</i>) AND THE WESTERN FLOWER THRIPS (<i>Frankliniella occidentalis</i>)	303
Viktor József VOJNICH, Adrienn SZARVAS	
4.13. STEM RUST RETURNS, OLD – NEW RYE PATHOGEN	307
Beata WIELKOPOLAN, Marcin BARAN, Magdalena JAKUBOWSKA	
4.14. APPLICATION OF HERBAL ADDITIVES TO DEVELOP NEW TYPES OF NATURAL SNACKS: PROCESSING ASPECTS	311
Agnieszka WÓJTOWICZ, Katarzyna LISIECKA, Marcin MITRUS, Tomasz ONISZCZUK, Maciej COMBRZYŃSKI, Karol KUPRYANIUK, Abdallah BOUASLA, Kamila KASPRZAK, Anna ONISZCZUK	
4.15. USE OF SELECTED CEREAL BRAN DEPENDING ON THE CONTENT OF SELECTED ELEMENTS	317
Wioletta ŻUKIEWICZ-SOBCZAK, Paweł SOBCZAK, Anna ROGÓZ-MATYSZCZAK, Daniel TOKARSKI, Klaudia WOLYŃCZUK, Marcin WEINER	
5. MANAGEMENT AND ECONOMICS	321
5.1. PERFORMANCE OF A CHESTNUT VACUUM HARVESTER – FIRST RESULTS	323
Arlindo ALMEIDA, Ângela MONTEIRO	
5.2. EFFECTIVE BIOMASS SUPPLY MANAGEMENT AS A FACTOR OF SUSTAINABILITY OF ECOSYSTEMS	329
Waldemar BOJAR	
5.3. UNIFICATION OF TECHNOLOGICAL PARAMETERS OF GRAIN LOGISTICS IN CORPORATIONS	335
Volodymyr BULGAKOV, Valerii ADAMCHUK, Natalia SERGEEVA, Volodymyr KOLODIUCHUK, Vasyl DMYTRIV, Semjons IVANOV	
5.4. REPLACEMENT OF THE MACHINERY PARK IN SELECTED FARMS OF MALOPOLSKA REGION	341
Michał CUPIAŁ, Marcin KOBUSZEWSKI	
5.5. BELCAM - A COLLABORATIVE AND INNOVATIVE WEBPLATFORM SERVING FARMERS NEEDS	347
Yannick CURNEL, Dimitri GOFFART, Jean-Pierre GOFFART, Cindy DELLOYE, Pierre DEFOURNY, Viviane PLANCHON	
5.6. CONSUMER ATTITUDES AND BEHAVIOUR ON THE MARKET OF REGIONAL AND TRADITIONAL FOOD PRODUCTS	353
Agnieszka DUDZIAK, Monika STOMA, Grzegorz ZAJĄC, Andrzej KURANC, Tomasz SŁOWIK, Joanna SZYSZLAK-BARGŁOWICZ	
5.7. APPLICATION OF RADIO FREQUENCY IDENTIFICATION IN SUSTAINABLE AGRICULTURE	359
Sławomir JUŚCIŃSKI	
5.8. EFFICIENCY OF MATERIAL AND ENERGY EXPENDITURE AND THE DIRECTION OF FARMS PRODUCTION	365
Sławomir KOCIRA, Kamil DEPO, Agnieszka SZPARAGA, Pavol FINDURA	
5.9. SELECTED QUALITY IMPROVEMENT INSTRUMENTS USED IN THE AREA OF PRODUCTION SERVICES FOR AGRICULTURE	371
Anna KRAWCZUK, Sławomir KOCIRA, Katarzyna Kozłowiec	
5.10. PRECISION AGRICULTURE EFFECT ON FARMERS' INFORMATION NEEDS	377
Edmund LORENCOWICZ, Jacek UZIĄK	
5.11. THE ROLE OF PRODUCTION GROUPS IN UPGRADING THE MACHINE PARK IN FARMS	383
Anna SZELAĞ-SIKORA, Zofia GRÓDEK-SZOSTAK, Joanna STUGLIK, Marcin NIEMIEC, Sylwester TABOR, Radosław KOWALSKI	
5.12. THE INFLUENCE OF ENERGETIC AND MATERIAL INPUTS ON THE SUSTAINABILITY OF AGRICULTURAL PRODUCTION	389
Zbigniew WASĄG	
6. ENVIRONMENT AND ERGONOMICS	393
6.1. IMPACT OF AGRO-ECOLOGICAL SERVICE CROPS AND THEIR TERMINATION STRATEGIES ON SOIL MINERAL NITROGEN AVAILABILITY, SOIL HUMIDITY, WEEDS DEVELOPMENT AND CABBAGE HARVEST	395
Donatienne AROTTI, Hanne LAKKENBORG KRISTENSEN, Stefano CANALI, Stefaan DE NEVE, F. Xavier SANS SERRA, Gilles SAN MARTIN, Bruno HUYGHEBAERT, Didier STILMANT	
6.2. ASSESSMENT OF DIFFERENT MEANS TO REDUCE THE POTENTIAL EXPOSURE TO PESTICIDES OF RESIDENTS LIVING IN THE VICINITY OF TREATED FIELDS	401
Bruno HUYGHEBAERT, Suzanne REMY, Christophe FRIPPIAT, Matthieu VESCHKENS, Jean-Luc HERMAN, Nathalie DUCAT, Olivier PIGEON, Bruno SCHIFFERS, Ingrid RUTHY	
6.3. THE SUSCEPTIBILITY OF SUGAR BEET VARIETIES TO THE PRESENCE OF SPIDER MITES (ACARI: TETRANYCHIDAE) IN RELATIONSHIP TO ENVIRONMENTAL CONDITIONS	407
Magdalena JAKUBOWSKA, Jan BOCIANOWSKI, Beata WIELKOPOLAN, Kamila ROIK, Jolanta KOWALSKA	

5.1. PERFORMANCE OF A CHESTNUT VACUUM HARVESTER – FIRST RESULTS

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Keywords: mechanization, chestnut orchard, harvester work rate.

ABSTRACT

In Portuguese chestnut producing regions, harvest is mostly manually. Nowadays it's difficult to find available labour. Harvest mechanization is a solution if some difficulties of actual harvesting systems, are solved. Currently the equipment available is not completely suitable to work under high humidity conditions and high concentration of leaves and chestnut burrs, conditions that can jeopardize equipment performance. Another difficulty is pointed out by the agro-industry that complains that chestnut mechanically harvested appear with stone, branches and other materials that depreciate their value. It is important to improve harvesting procedures. Equipment performance knowledge is an important step to find solutions for problems mentioned. In 2018 harvesting season, field trials took place in a chestnut orchard in Northeast of Portugal to get information of equipment performance. This paper presents work rate preliminary results of one vacuum harvester.

INTRODUCTION

In Portuguese chestnut (*Castanea sativa*) producing regions, harvest is mostly manually, collecting from the soil previously fallen chestnuts.

In the last decades chestnut harvesting machines are available in the market, in continuous technological evolution. The use of this equipment has reduced the harvesting time and the associated costs. It is also an answer to the lack of labour required for manual harvesting. Consequently it has been an alternative to traditional manual harvesting (Monarca, D. *et al.*, 2014a).

There are two main categories of chestnut harvesting machines: vacuum-type harvesters and mechanical pickers (Monarca, D. *et al.*, 2014a). These two types of equipment are commercially available trailed, mounted and self-propelled. It is expected that mechanical harvesting provides an improved quality of chestnuts, because a better work rate can reduce the time in which the fruits stay on the ground. The chestnuts must not remain too long in contact with the ground to prevent its desiccation, contamination by fungi and the risk that they might be attacked by rodents. However, for farmers fully enjoy these advantages, some aspects of the operation need to be improved: to reduce fruits damages caused by equipment and to improve equipment performance under high humidity conditions common during harvesting season. Chestnuts harvested with the equipment currently available in the market may not have better quality than the fruits manually harvested. In addition to the chestnut, some stones, branches and other inert are harvested, that by abrasive effect, damage the integrity of the chestnut and depreciate its commercial value, especially for fresh consumption. The percentage of damaged fruit is higher when harvested mechanically than when harvested manually. The most common damage assessment refers to: petiole absence, superficial scratches, visible strokes and tears in the epidermis, and deep abrasions affecting a thicker layer of the epidermis (Monarca, D. *et al.*, 2003; Monarca, D. *et al.*, 2005; Monarca, D. *et al.*, 2014b).

It is important to improve harvesting procedures and to improve the quality of work done by machines. Equipment performance knowledge is an important step to find solutions for problems mentioned.

MATERIAL AND METHODS

Field trials sites

Field trials took place in November 2018 in Northeast Portugal (41° 39' 35"N 6° 50' 46"W - altitude 885 m) over an area of 4275 m² with a slight slope (up to 5%) in an orchard of “Judia” cultivar, 25 to 35 years old, tree spaced 9.5 m x 9.5 m (site 1) (Figure 1). In this site was collected data to evaluate equipment work rate and work speed.



Fig. 1. Site 1.



Fig. 2. Harvesting equipment *Facma Cimina 380*.

In a site 2, similar and near site 1, but with an area of 4250 m², was collected data to evaluate work speed.

Harvesting equipment used

A vacuum self-propelled harvester *Facma Cimina 380* was used (Figure 2). The characteristics of this equipment are in Table 1.

Table 1. Equipment characteristics.

Traction	Two rear-wheel drive with hydraulic transmission
Length (mm)	5950
Height (mm)	1890
Width (mm)	1770
Harvesting width (mm)	3000
Weight (kg)	2630
Power (kW)	74

The equipment has a centrifugal fan to produce the vacuum that picks up the material from the soil surface and is also used to separate the fruit from the burrs, leaves, small branches and others inert (Guyer, D. E. *et al.*, 2012).

Harvesting methods

The machine collected chestnuts from the soil in the area between rows traveling three times as shown in Figure 3. After the last of these three passes, the machine went to harvest in the next inter row area. Time for harvesting in each inter row includes time

spent to turn over inside each inter row. There is a harvest interruption in the turns between inter rows.

Chestnuts collected are temporarily stored in a semi-trailer pulled by the harvesting equipment with a capacity of approximately 1000 kg.

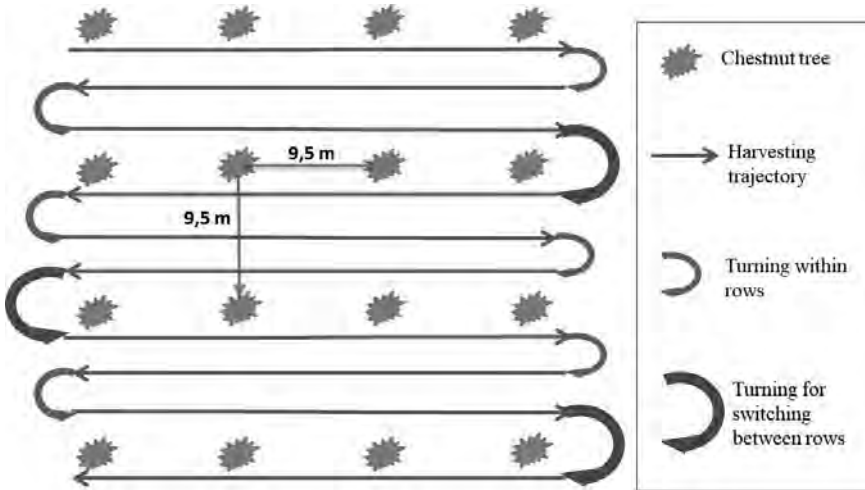


Fig. 3. Trajectories of harvesting equipment.

Work speed evaluation

The average work speed was evaluated by measuring with a chronometer the time spent by equipment between turns and relating this to the space travelled.

This data was obtained in two sites. Site 1 with three repetitions, and site 2 with four repetitions.

Equipment work rate evaluation

To evaluate the equipment work rate, time for each elementary operation was measured with a chronometer: harvesting time; inoperative time; turning time within two rows (during which harvesting continues) and turning time for switching between rows (during which harvesting stops). Inoperative time refers to the interruption of work to clear the product flow in the internal equipment parts.

Working rate was evaluated by the ratio worked area / time, in $\text{m}^2 \cdot \text{s}^{-1}$ and $\text{ha} \cdot \text{h}^{-1}$

The total working time results by the sum of each elementary operation. Total harvesting time is obtained by adding harvest time to turning time within each row.

Total working time, because it includes turning times when harvesting is interrupted and inoperative time, is higher than harvesting time.

Harvesting performance is assessed by field efficiency: ratio between the sum of elementary operation time during harvesting and total working time. Field efficiency is expressed as a percentage, reporting the ratio of the time a machine is effectively operating, to the total time committed to the operation. (Hunt, D. 1983).

RESULTS AND DISCUSSION

Work speed

Average work speed: 0.96 km.h⁻¹ to 1.47 km.h⁻¹ or 0.27 m.s⁻¹ to 0.41 m.s⁻¹.

Table 2. Work speed in site 1

Distance (m)	Time (minutes)	Medium work speed (km.h ⁻¹)
40	2.55	0.96
	2.73	
	2.25	

Table 3. Work speed in site 2

Distance (m)	Time (minutes)	Medium work speed (km.h ⁻¹)
169.5	6.31	1.47
	7.45	
	6.6	
	7.5	

Equipment work rate

Table 4 shows harvesting elementary operations time in field tests.

Table 4. Elementary operations time

Elementary operations (minutes)		Total elementary harvesting operations (minutes)	Total elementary non harvesting operations (minutes)
Harvesting	51.85	54.94	12.05
Turning within two rows	3.09		
Inoperative	5.8		
Turning for switching between rows	6.25		
Total		66.99	

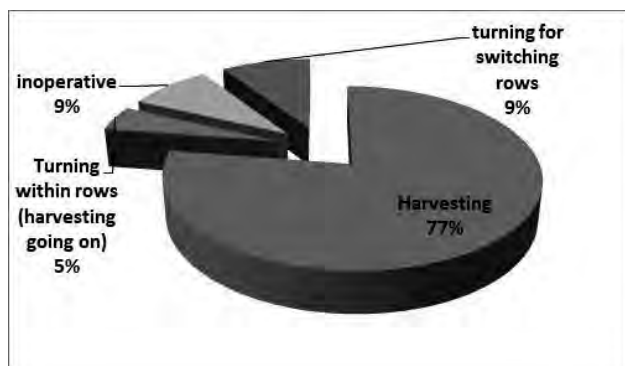


Fig. 4. Elementary operations time expressed as percentage of total time.

Considering 66.99 minutes to complete harvesting in 4275 m², results in these preliminary tests, a work rate of 0.383 ha.h⁻¹ or 1.064 m².s⁻¹.

Field efficiency is 82%. This field efficiency value is satisfactory.

Inoperative time is 8.7% of the total. As observed in field tests, with higher humidity, and with many leaves on the soil, the equipment becomes less efficient or even inoperative as a result of obstruction / clogging of product flow inside equipment. In

these situations, not represented in this paper, a relative increase in inoperative time is expected.

The amount of chestnuts harvested was 700 kg (approximate value), resulting in 630 kg.h⁻¹, which is in accordance with references (Monarca, D. *et al.*, 2003; Monarca, D. *et al.*, 2005).

These are preliminary performance results. It is necessary to continue field tests with this equipment and others available in the market.

CONCLUSIONS

With manual harvesting it is expected to harvest 20 kg.h⁻¹ to 30 kg.h⁻¹ per person (Monarca D. *et al.*, 2003; Monarca D. *et al.*, 2014a). The results obtained in these preliminary tests point to a remarkable increase in the harvesting work rate with a vacuum harvester. This advantage makes it easier to match the time available to harvest preserving fruit best quality, with the area to be harvested. The reduction in the time necessary makes easier the double harvesting to reduce the period of fruit contact with the moist soil, with advantage for the chestnut sanitary conditions. Double harvesting means to harvest the same area twice. This procedure can be considered necessary because chestnuts are falling to the ground over a period of three or four weeks.

Results show an inoperative elementary operation of 8.7% of total time, necessary to clean the product flow inside of equipment. This slows down the work rate. To solve this problem it is important to improve the chestnut cleaning procedure inside the equipment.

Mechanical harvesting is also a solution to the labour shortage for this operation. In future work, fruit damage should be evaluated and harvesting costs evaluated.

Harvesting costs must be evaluated for a better understanding of mechanical harvesting advantages. Costs of manual and mechanical harvesting must be compared.

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